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Report No. 89.

DURABILITY AND ECONOMY IN PAPERS FOR PERMANENT RECORDS.

A REPORT SUBMITTED BY
H. W. WILEY, *Chief of Bureau of Chemistry*, and C. HART MERRIAM,
Chief of Bureau of Biological Survey, Committee on
Paper for Departmental Use.

INCLUDING

PAPER SPECIFICATIONS,

BY
F. P. VEITCH,
Chief, Leather and Paper Laboratory, Bureau of Chemistry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Washington, D. C., January 4, 1909.

The Secretary of Agriculture:

The committee on paper for departmental use, appointed by you at the last meeting of the department council, respectfully reports:

In view of the great value to mankind of the results of scientific research and discovery achieved and published in the various bureaus of the Government; and in view of the fact that the paper on which these results are now published is highly perishable, its life in many instances being only a few years, we urgently recommend that the necessary steps be taken to secure the printing on durable paper of at least part of the edition of each publication of lasting value, so that copies may be permanently preserved in the Library of Congress and other great libraries in this country and abroad.

In the spring of 1904 you authorized the Bureau of Chemistry to investigate the subject of suitable papers for government purposes. Since then this work has been conducted as the force and facilities at command permitted. The investigation has been based chiefly on the large number, about 5,000 samples, of papers referred to the bureau for testing by the several federal departments. These samples have been supplemented by gift and by purchase.

Three reports have been prepared in the Bureau of Chemistry by F. P. Veitch, Chief of the Leather and Paper Laboratory, embodying the results of these investigations and the conclusions drawn therefrom. The first, already published as Circular 41 of the Bureau of Chemistry, is entitled "Paper-Making Materials and their Conservation," and deals with the use of well-known materials, discusses the factors governing the most profitable utilization of the most promising materials that have been experimented with for paper making, and points out the ways in which paper-making materials may be conserved.

The second is the manuscript of an article to be published in the 1908 Yearbook, entitled "Suitable Papers for Permanent Records," and enumerates the factors that determine the durability of papers, describes the methods of determining the quality, and discusses the proper care of important publications and records.[a]

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[a] These two reports, being readily available, are not here reprinted.

The third, a manuscript entitled "Paper Specifications," is presented herewith. It enumerates and discusses the factors governing the quality and durability of papers for various purposes, describes the methods of the Bureau of Chemistry for testing paper, and gives specifications for practically all kinds of paper.

The committee has summarized the data relative to the suitability of paper for departmental work and recommends certain broad, general specifications for various kinds of paper, referring to the manuscript on "Paper Specifications" for the details, which insure that papers of the desired characteristics will be secured. The committee is of the opinion that the interests of the Government would be greatly promoted if all the paper purchased for its use were brought under the complete and definite specifications embodied in "Paper Specifications."

Respectfully submitted.

H. W. Wiley,
C. Hart Merriam,
Committee on Paper for Departmental Use.

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DURABILITY AND ECONOMY IN PAPERS FOR PERMANENT RECORDS.

RECOMMENDATIONS OF THE COMMITTEE.

GENERAL CONSIDERATIONS.

The quality of paper is controlled by the raw materials from which it is made and by the methods used in making it. The strongest and most durable paper is made of first-class materials, such as the best grades of cotton, linen, and hemp rags and spinning wastes, which are prepared and made into paper by the methods which experience has shown most largely maintains the strength and pliability of the raw materials and renders them least liable to subsequent deterioration. Paper of lower quality is made from rags of inferior grades, from bleached chemical wood, straw, and other raw material, or from mixtures in any proportion of two or more of these. Paper made either of good or of poor materials is weakened and thus rendered less durable by acids, by the addition to it during manufacture of mineral fillers, by large amounts of sizing materials, and by rapid drying at high temperatures. The filler is added to increase the weight, to improve the printing quality, and to increase opacity; the sizing is added to prevent the spreading of ink, and the acid is formed while the paper is being made and is often not completely washed out.

The kind of raw material or stock in paper can be determined, but the quality of this raw material can not, except as it imparts certain general qualities, such as great strength, pliability, and resistance to chemicals, to the paper made therefrom.

Weight and bulk are properties which should not be neglected in the consideration of suitable papers. The general statement may be made that paper should be no heavier nor more bulky than necessary. Libraries and the public are relieved of the inconveniences and expense of handling and shelving useless material, transportation charges are reduced, and raw materials are conserved.

The cost of paper for government purposes could be considerably lessened by employing better, lighter, and thinner paper, and storage space could be reduced from 10 to 50 per cent. The maximum of each desirable characteristic which a given paper should possess can not be secured. Thus, a paper can not have the maximum strength, durability, opaqueness, and the minimum weight and bulk. If great strength and durability are desired, opaqueness must be largely sacrificed, as the strongest and most durable papers are relatively transparent and thin. If great opacity is required, strength, durability, lightness, and thinness must all be sacrificed to a certain extent. The characteristics of any paper are therefore the results of a compromise among opposing qualities, and the nature of this compromise is predetermined by the purpose for which the paper is to be employed.

It should also be noted in this connection that, with equal care in printing, as fine presswork can not usually be done on light, thin paper as on thick, heavy paper. For this reason the latter is often preferred by publishers. The papers for which detailed specifications are given herein are not proposed for those cases in which the very best presswork, at the lowest cost and with the least effort, is the important or controlling factor. These facts only further emphasize the necessity of considering the nature of the publication and the purposes for which it is issued in determining the character, quality, and weight of the paper to be used. While the lighter papers described in this report will not, therefore, be suitable for limited editions in which the finest presswork is desired, they will give good results as to presswork with a maximum of durability and economy, and are therefore preeminently suited for the great majority of the government bulletins which are issued in large editions and for those which should form permanent records. It must be remembered in using the data here given that the fundamental purpose of this investigation was to provide suitable papers for government use, durability and economy being the main consideration, to which appearance has been in part subordinated.

Surface and color are important properties of printing and writing papers. Highly polished and very white papers are decidedly injurious to the eyesight and when looked at continuously for long periods often produce headache. For these reasons, as well as others, coated, supercalendered, and very white papers should not be used when they can be avoided. Rough surface and papers of a creamy color are far less harmful.

Applying these facts to papers for departmental use the committee makes the following recommendations:

PRINTING PAPERS.

Those departmental publications which are distributed to the public should be printed on paper made from bleached chemical wood or its equivalent. This paper should be as light and thin as is compatible with sufficient strength and opacity, and its surface and color should not be injurious to eyesight. For bulletins and circulars of all kinds a paper weighing 40 pounds per ream 25 by 38 is sufficiently heavy, while for large volumes containing 600 or more pages somewhat thinner and lighter paper should be used. Fourth-grade printing paper according to the specifications on page 35 is recommended for this purpose.

A small edition of each publication, or certainly of those of scientific value, should be printed on high-grade paper for distribution as permanent records to public and institution libraries. This paper should consist of at least 75 per cent rag stock, should be strong and thoroughly well made to withstand much handling. For such use second-grade printing paper according to the specifications on page 33 is recommended. Papers of the weight stated above may be used. When half-tone illustrations are not used in the text the surface should be what is known as "machine finish" and the color "natural."

Coated paper for half-tone illustrations should be used only when absolutely necessary. No other kind of paper is now known upon which half tones showing a great amount of detail can be printed as successfully as upon coated papers. The low quality of these papers, their great weight, the fact that if they get damp they are certain to stick together and thus be ruined, and the great cost and difficulty of successfully binding them into a volume constitute ample grounds for largely discarding these papers in departmental papers, even though as effective illustrations can not be secured with other papers. For the illustrated portions of nondurable publications a well supercalendered paper, suitable for both the illustrations and the text, is recommended, on the score of both economy and durability. A paper of this kind is more durable than the ordinary coated book. Half-tone screens containing as many as 120 lines per inch may be used on a well supercalendered paper.

For permanent publications a loaded and supercalendered paper containing 75 per cent of rag stock, or an unloaded, plated, or supercalendered paper containing 75 per cent of rag stock is recommended. On the former illustrations made with a 150-mesh screen may be employed and on the latter those made with a 130-mesh screen.

Experiments are now being made in the Bureau of Chemistry to determine more definitely what mesh screen can be most advantageously employed on various papers. In those cases where it is essential to bring out the minute details of illustrations coated papers must be employed. But unless the cuts are printed on both sides of the paper it should be coated on but one side, and should rarely be heavier than 75 pounds per ream 24 by 36, 500.

Detail specifications for all kinds of printing papers are given on page 31 et seq.

WRITING PAPERS.

Ledger and other accounts partaking of the nature of permanent records should be placed on paper made in the best possible manner of new rags, chiefly linen. Correspondence papers, though not always used for permanent records, are most properly well-made rag stock papers. Carbon copies are permanent records, and all rag stock paper should be employed. Envelopes which have but temporary use may be made of lower-grade materials. Index cards, so largely used in departmental work, should be made from heavy ledger paper.

All writing papers should be as light and thin as is consistent with satisfactory service. The storage and safe-keeping of government records is a problem increasingly difficult to solve, but one which may be simplified by reducing their bulk and weight as much as practicable. Specifications for all grades of writing papers are given on page 45 et seq.

WRAPPING PAPERS.

These papers are intended, as a rule, for but temporary use. They need not be purified, as more permanent papers are. The chief requirements here are strength, flexibility, and a certain degree of water resistance. The so-called "manila envelopes," so many of which are used in departmental work, are made of papers of this class.

These papers should also be as light and thin as is consistent with satisfactory service. Detail specifications for several grades of wrapping paper are given, beginning on page 49.

PAPER SPECIFICATIONS.

By F. P. Veitch.

Chief, Leather and Paper Laboratory, Bureau of Chemistry.

LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry, Leather and Paper Laboratory,
Washington, D. C., December 23, 1908.

Sir: Four years and a half ago an investigation of papers, with special reference to their suitability for government use, was authorized by the Secretary of Agriculture. This report embodies the results of the investigation made, in so far as they relate to the factors which determine suitability for various purposes, and embraces specifications for all of the most important classes of papers. Before these could be drawn up, a most painstaking and extensive examination of such papers was necessary.

It is my conviction, founded both on technical and on practical tests, that the interests of the Government would be better served by purchasing all of its papers on the basis of complete and definite specifications. Nor are the interests of the Federal Government alone to be considered. The preservation of state, county, and municipal records is of the greatest importance, and it is imperative that these also be placed on the most durable paper that can be produced.

Again, papers of the highest quality and the smallest practicable bulk and weight should be used in public and other large libraries, where not only durability, but also space and weight must be carefully considered. Such individual and corporate consumers, newspapers, and magazines as buy in large quantities will also find the data submitted of practical value in guiding their purchases.

The interests of the people at large demand that the paper supply shall serve the purposes for which it is employed as efficiently and as economically as possible, and, further, that in the production of suitable papers the waste of raw materials now occasioned by the manufacture of needlessly large amounts of inferior papers shall cease.

Respectfully,

F. P. Veitch,
Chief, Leather and Paper Laboratory.

H. W. Wiley,
Chief, Bureau of Chemistry.

INTRODUCTION.

A cursory examination of the paper used in current publications and records shows that they are open to serious criticism, in that they are of inferior quality, needlessly heavy and bulky, and, because of the highly polished surface so frequently given them, injurious to the eyes. It is the purpose of this bulletin to point out how these conditions may be remedied, to enumerate the chief factors which control the quality of papers, and to suggest general specifications for papers which will be suitable for the various purposes for which they are employed, whether these be permanent records or package wrappings. These specifications are prepared with particular reference to their suitability for government and state use, for publications, records, and periodicals in which utilitarian rather than esthetic considerations control. It may be said, however, that from either point of view a desirable paper can not depart materially from these specifications as to quality, but it may vary as to weight, thickness, and finish to suit varying requirements and individual tastes. These specifications are not necessarily final. It may be that better and more suitable papers than those specified can be made, or that developments in paper testing may add to or eliminate some of these requirements. It is not deemed wise, however, to depart more decidedly from the present practice of making ordinary papers nor to introduce other tests and requirements with which the paper-making industry is generally unacquainted. It is true that it is not difficult to make papers complying with these specifications, and also with other tests which might be included; but the unfamiliarity of the paper maker with these tests and the fact that suitable apparatus for making them is not generally in his hands would hamper the efforts to secure better papers and greatly increase their cost were they introduced at this time.

FACTORS DETERMINING THE QUALITY AND DURABILITY OF PAPER.

STOCK.

The quality of paper is controlled primarily by the kind of stock used in making it and the methods by which it is made. Durability is controlled not only by the stock and the methods and conditions of manufacture, but also by the conditions of use and storage to which it is subsequently subjected. At present, paper is made from cotton, linen, and hemp rags, and waste, from chemically treated woods, from straws, from esparto, and from wood not chemically treated. As the fibers of cotton, linen, and hemp are longer than those of the other substances commonly employed, and as they consist of a very pure form of cellulose, which is exceedingly resistant to all changes, such materials when new yield papers of the highest quality and greatest durability, and where high quality and durability are desired in a paper no other material should be used. (Japanese paper, made by careful methods from several varieties of plants, is much superior to paper made in this country. The supply of this paper is so limited, however, that it need not be taken into consideration at this time.) It is proper to state, however, that paper made from properly prepared chemical wood fiber has endured from the time of the practical introduction of this fiber to the present, a period of less than fifty years. Exact knowledge regarding the durability of these fibers as compared with cotton and linen fibers must be wanting for possibly many years, and until durability is proven by time the wood fibers should not be used in papers of permanent value, except in small quantities.

It must not be inferred from the foregoing that all papers made from rags alone are more durable and stronger than papers made from other raw materials. Low quality rags or severely treated rags may yield a weaker or less durable paper than is produced from materials which in the original state are inferior. Chemically treated wood, straw, and esparto have much shorter fibers than rags and also contain compound celluloses which are subject to change, resulting in the slow disintegration of the papers made therefrom. What is known as "mechanical" or "ground" wood has even shorter fibers, and contains, in addition to compound celluloses, other bodies which are subject to very rapid decay. This material should only be used for paper which has but a transient value.

PROCESSES OF MANUFACTURE.

The conditions under which paper is made also greatly affect its quality; a pulp which has been undercooked or overcooked or overbleached will yield an inferior and comparatively short-lived paper. The general appearance, uniformity of felting, strength, and durability are all affected by the way the stock is handled in the beating engines, and by the speed with which the paper is made and dried. Strength and durability are affected also by the presence of bleaching agents, mineral salts, excessive quantities of sizing material, and free acids. All of these act more or less rapidly on the fibers of the paper and slowly disintegrate them, so that in time the paper becomes weak and brittle. For this reason paper should contain no free acid nor soluble salts which may yield acids in the paper.

Excess of rosin size is another cause for the deterioration of paper, as the rosin gradually oxidizes, forming free acids. A rapidly made paper dried at high temperature is not of as high quality, nor as durable, as the same paper made more slowly and dried at lower temperatures.

EXTRANEOUS INFLUENCES.

The durability of paper is further affected by bacteria, insects, and the conditions under which it is stored. The action of bacteria and of insects is largely controlled by the composition of the paper. Bacteria will thrive wherever food, moisture, temperature, and reaction of the material are suitable. Of these factors that of temperature is practically beyond control. On the other hand pure cellulose is but slowly attacked, and then only under favorable conditions. Albuminoid and other noncellulose substances, such as glues, casein, starch, and sugars, are the food of bacteria, and when present in a paper it is more likely to be attacked by them. None of these substances is used by bacteria, however, except in the presence of moisture, and then most rapidly when the material has a faintly alkaline reaction. Moisture in paper is not controlled entirely by atmospheric conditions. The presence of soluble salts, particularly chlorids, increases the percentage of moisture in a sheet of paper and thus facilitates the action of bacteria. While an alkaline paper is probably more rapidly attacked by bacteria than an acid one, free acid will itself destroy paper, and for these reasons paper should be neutral.

A number of different kinds of insects are injurious to paper. These insects feed upon the starch and glue which the paper contains, and in seeking their food seriously injure it. Paper containing no starch, glue, or other nitrogenous sizing material is least attacked by insects.

When paper is exposed constantly to fumes, particularly to acid fumes, such as are produced by gas lights, its durability is decreased in the same way that the durability of paper containing free acids is decreased. It is important, therefore, that the atmosphere where paper is stored for long periods be kept as fresh, pure, and dry as possible.

Finally, frequent handling shortens the life of paper, and probably is the chief direct agent in its disintegration, deterioration of paper from any cause revealing itself through lessened resistance to handling. As it is the expectation that paper will be handled, nothing further need be said on this point other than that the more resistant the paper to other destructive agencies the more resistant in general it is to handling. Further, the form in which paper is employed should be that which subjects the paper to no avoidable strains. Frequent folding or improper binding, either too tight or too loose, are among the chief avoidable causes for deterioration under handling.

From the foregoing it is evident that the best and most durable papers, made from given materials, are those which have been properly cooked and bleached, contain no free bleaching agents, have been well washed to remove soluble salts, do not contain free acids, have been sized with a minimum quantity of sizing material, have been beaten to give the greatest strength consistent with the maximum flexibility, have been made on the machine at not too great speed, and have been dried at low temperature.

Manifestly the purchaser of paper can not know, even by the most careful examination, that it has been made in accordance with the best methods known to paper makers, except as these methods reveal their effects indirectly to certain chemical, physical, and microscopical tests. Not all paper need be of the highest quality and greatest durability. The quantity of raw material available will not permit this, nor do the purposes for which the paper is used always justify it. Low-grade materials may therefore quite properly be mixed with high-grade or used alone, the proportions of the mixture being governed by the character of the paper desired and the purposes for which it is to be used. The methods of manufacture, however, should always be such that the stock will yield the highest quality paper which can be profitably produced from it.

WEIGHT AND BULK.

Paper that is well made and of good materials does not meet all requirements. From the broad economic point of view it is highly important that the consumer be not burdened with an unnecessary weight or bulk of material, and that raw materials be conserved. For these reasons papers should not be needlessly heavy nor bulky. Any additional weight and bulk beyond what is necessary to secure sufficient strength, opacity, and resistance to wear and tear results in lessened durability, greater cost of handling and transportation, needless consumption of raw materials, increased space for storage, and inconvenience in handling. Printing papers as a rule weigh 48 pounds or more per ream (24 by 36 inches), and are from 0.0035 to 0.0070 inch thick. Eighty and 100 pound ledgers, heavy writing, and bond papers might frequently be replaced with papers from 10 to 30 pounds lighter per ream, particularly if the quality of the paper is improved at the same time. It not infrequently happens that a 100-pound wrapping paper has no greater strength than a 50-pound paper made of the same materials. As strength and pliability are the essential characteristics of wrapping paper, the 50-pound paper at double the price per pound of the 100-pound paper is the cheaper. The saving in raw materials, labor, and buildings, and in freight, express, and mailing expenses which would result from the use of lighter and better paper would go far toward paying the extra expense of making it. Without sacrificing quality, weight and thickness may be reduced from 10 to 50 per cent with benefit to the public.

LOADING.

It is customary to add to printing papers and to some writing papers during their manufacture china clay, sulphate of lime, or other white insoluble mineral matter partly for the purpose of improving the printing qualities of the paper and rendering it more opaque. The quantity of loading contained in machine-finish and in supercalendered printing papers varies from 2 to 30 per cent and in coated papers from 12 to 35 per cent. In writing paper it seldom exceeds 10 per cent. The addition of loading materials is detrimental to the strength and durability of paper. They add weight, and, having no fiber themselves, weaken the paper and decrease its resistance to wear. While it is true that the use of loading furnishes a way to secure good printing qualities and greater opacity, both of these qualities may be sufficiently secured by the use of less loading than is generally added and by means that are not harmful to the paper itself. The use of loaded paper should be avoided whenever practicable. For particular purposes, such as fine half-tone work, the minimum amount which will yield satisfactory prints may be permitted. Unloaded paper can be used for half-tones, but does not permit the detail secured with loaded paper. The addition of loading materials to writing or wrapping paper is seldom justified and should be permitted only in rare instances.

METHODS OF PAPER TESTING.

The quality, durability, and suitability of paper for stated purposes are chiefly judged from chemical, physical, and microscopical examinations. While this work is well developed in Europe, but few systematic tests of paper were made in this country until the work was taken up by the Bureau of Chemistry five years ago, where it has been conducted in constantly increasing quantities since. The equipment and experience of the bureau enable it to meet all demands of the government departments for work of this character.

Experience has demonstrated that the long-fibered materials which yield a nearly pure normal cellulose, such as cotton, flax, hemp, etc., make the most durable and strongest papers. Determinations of the kind of fiber and of strength are therefore those which are generally made in paper testing. As a rule, the better the stock or fiber the stronger the paper. Strength, therefore, has been regarded almost universally as the chief factor in paper testing and in determining the value of paper within the use-classes into which it is divided. It may be said at once, however, that paper testing is yet in its infancy and the results obtained can not be interpreted, in the present state of our knowledge, so as to yield all the information desired; hence it may be that the tests now made may be needlessly elaborate on the one hand or inadequate on the other. With more experience undoubtedly paper tests will be developed which will yield more definite results. The methods used in the Bureau of Chemistry in paper testing are as follows:

SAMPLING.

Paper testing is valueless if the sample examined does not truly represent the paper, and paper sampling is most difficult. A large lot of paper, for instance a carload, is never identically alike in all particulars, and even as small a lot as 1 ream may have material differences within itself. These differences are due chiefly to the methods of paper manufacture. The stock is never accurately weighed, but is calculated or assumed from previous weighing and measurement. Experiments conducted by this bureau indicate that with the greatest care the error in the quantity of stock put in the beater is not greater than 10 per cent and that the error in the percentages of different kinds of stock used may be 5 per cent. These experiments indicate, and paper makers claim, that the percentages of the several kinds of fiber in the paper can be controlled, as a rule, within 5 per cent. Therefore a greater variation than this from the specification is due to avoidable causes.

The materials furnished to different beating engines, in which they are thoroughly mixed, may be all mixed together in a stuff chest, from which they go to the paper machine and are made into paper, or the contents of the several beaters may pass successively to the paper machine. It is clear that in the first case any differences in proportions or in the way the stock was beaten in the different engines may be corrected by the mixing in the stuff chest, and the paper should be uniform in stock, thickness, weight, and strength, provided the machine is run uniformly. A sample taken from one portion of such a lot of paper would be fairly representative of the whole lot. In the second case, however, where the contents of the beaters pass individually and successively to the machine, the stock and the effect of the work of each beater, which may show itself in strength, formation, thickness, and weight, may vary, in fact it almost certainly will vary, and samples which do not accurately represent the paper made from each beater do not represent the entire lot. It is this uncertainty, or rather the certainty that a large lot of paper does differ in stock, formation, finish, weight, thickness, and strength, in fact in all its properties, that makes correct sampling at once difficult of execution and essential as a basis for the testing work.

From the foregoing it is evident that samples should be drawn from a large number of different bundles or rolls of the paper. A single sheet 12 inches square taken from every tenth or twentieth bundle or roll of the paper and the whole tested as one sample will be found to answer all practical requirements. Too much stress can not be laid on the fact that a sample taken from a single roll or bundle can not be assumed to represent a lot of any size. The examiner, should, as far as practicable, ensure that each subsample for the different tests represents the entire sample. In a well-equipped laboratory this can usually be done without great difficulty, and in view of the unavoidable irregularities in paper making and the error incident to certain features of the testing work this is the only just method of procedure.

WEIGHT.

For the sake of uniformity and comparison, express the weight of all paper in pounds per standard ream of 500 sheets 24 by 36 inches. Determine by weighing a 24 by 36 inch sheet on a paper scale which gives directly the weight per ream, or, in case the paper available is too scarce, weigh an aliquot part of this sheet, for instance a piece 2 by 3 or 4 by 6 inches, on a suitable balance and calculate the weight per ream.

THICKNESS.

Determine thickness of a single sheet with a spring micrometer gauge reading accurately in ten-thousandths of an inch. The average of at least five readings should be taken.

ASH.

Determine by burning 2 to 5 grams in a porcelain crucible over a good bunsen burner until the residue contains no carbon, cool in a desiccator, weigh, and calculate percentage. If it be desired to determine the kind of loading material used in the paper, the ash is examined for bases and acids according to well-known methods of rock analysis. The ash is seldom as great as the loading or filler in the paper, because the filler contains water and other volatile constituents, which are driven off when the paper is burned. For this reason the filler in a paper may be 25 per cent greater than the determined ash.

SIZING MATERIALS.

QUALITATIVE DETERMINATIONS.

(1) *Starch.*—Moisten the paper with a solution of iodin in potassium iodid. The development of a blue color indicates the presence of starch.

(2) *Glue.*—Extract several grams of paper with 10 to 20 cc of hot water and to the clear cold liquid add an excess of a dilute solution of tannin. A white curdy precipitate proves the presence of glue or casein. Casein is insoluble in hot water except in traces and must be

brought into solution with dilute alkali. The solution is precipitated with dilute acetic acid, avoiding large excess. The rosin is extracted from the paper with 95 per cent alcohol before dissolving the casein in alkali.

(3) *Rosin.*—Extract a gram of the paper with 3 to 5 cc of 95 per cent alcohol and dilute the extract with about 20 cc of water. If rosin is present the solution becomes turbid.

QUANTITATIVE DETERMINATIONS.

Information of practical value as to how well the paper has been sized and its resistance to the penetration or spreading of ink on it is very rarely secured by making a quantitative determination of the sizing materials in the paper. This is done, therefore, only in exceptional cases. When such determinations are required the following methods are employed:

(1) *Glue and casein.*—Determine nitrogen in 3 grams of paper by the Gunning method. The result multiplied by 5.56 is considered as representing glue and casein. The error due to the small quantity of nitrogen naturally present in paper seldom exceeds 0.3 per cent. The quantity of glue and casein when both are present can not be separately determined. As far as is known, the quantitative determination of each of these when both are present is not of practical importance.

(2) *Rosin.*—Extract 10 grams of cut paper with 95 per cent alcohol, containing several drops of acetic acid, in a soxhlet, syphoning at least six times. Remove the alcohol to a dish and extract the paper again with fresh acidified alcohol, syphoning at least six times. Combine the extracts, evaporate to about 25 cc, transfer to a separatory funnel, dilute with about 150 cc of water containing a trace of salt to prevent emulsion, and dissolve the precipitated rosin by adding 25 cc of ether. Remove the water and wash it three times with ether, combine the ether washings and wash twice with water, transfer to a weighed dish, evaporate ether, dry at 100° in oven for exactly 1 hour, cool in desiccator, and weigh. Our experience indicates that this method is accurate to 0.2 per cent expressed on the paper basis. No other method so far proposed gives as accurate results.

(3) *Starch.*—No method known to this bureau for the determination of starch is accurate for all classes of paper.

GENERAL SIZING TEST.

Several more or less practical tests are in use for determining how well a sheet of paper has been sized. All of these are modifications of the simple procedure of writing on the paper with pen and ink and noting how rapidly the ink spreads or penetrates the paper.

The procedure generally employed in this laboratory is to note the spread in a given time of a drop of ink placed on the paper, and the time required for the ink to penetrate the paper. It is believed that this test furnishes all the data that can be interpreted.

TRANSPARENCY.

Usually when a sheet of paper is in use it has behind it a number of other sheets, and it is so held that the light falls upon the surface of the paper and does not pass through it from the opposite side. It should be borne in mind, therefore, that it is the transparency under these conditions which should be measured rather than the transparency to light shining directly through the paper. Transparency under the first conditions will vary greatly from that given in the latter case. In the first case surface, color, formation, loading, all exert their full influence. In the latter the effect of surface is practically eliminated and that of color greatly reduced, so that transparency is controlled almost entirely by the formation and loading of the sheet. This being true, it is practically impossible to compare the transparency of papers of different surface and color, as ordinarily used, by passing the light directly through them.

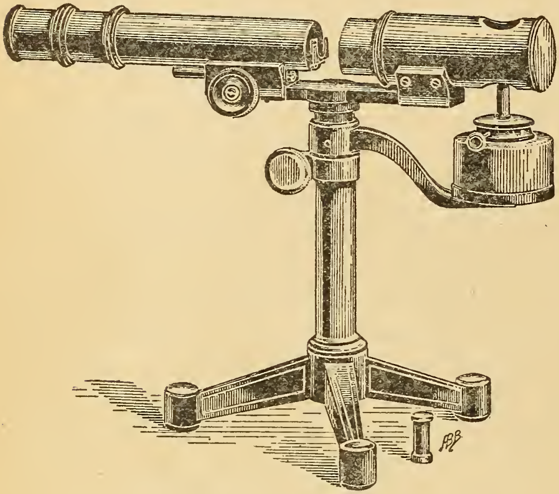

Fig. 1.—Instrument for testing transparency.

It frequently happens that a paper which is most transparent when looked through is least transparent when looked at. No satisfactory method has yet been devised for measuring the transparency of paper looked at. For measuring the transparency by looking through, the apparatus shown in fig. 1 is employed. Strips of the paper are placed in the instrument until the light of a 1-candlepower Hefner amyl acetate burner can no longer be seen through them. The transparency may be expressed in terms of the number of sheets required to cut out the light, in terms of the total thickness of paper, or as a factor of the weight per ream. It has been found that the candlepower of this flame need not be carefully controlled for ordinary papers. The results are the same whether a 1-candlepower or a 4-candlepower flame is employed.

STRENGTH.

In this country the machines most employed for determining strength operate by exerting pressure on the lower side of a circular disk of known area (fig. 2). The pressure required to break the paper is registered in pounds on an ordinary pressure gauge. This pressure is generally believed to represent the mean strength of the paper; that is, an average of the strength across and with the sheet. This is not true, however, experience indicating that strength as thus determined more nearly agrees with the strength of the paper in the cross direction, with the minimum strength, rather than with the average strength of the paper. Among the other objections to testers of this type is that to a certain extent the operator can influence the results at will, and even with the greatest care there is quite a wide difference between different tests of the same paper.

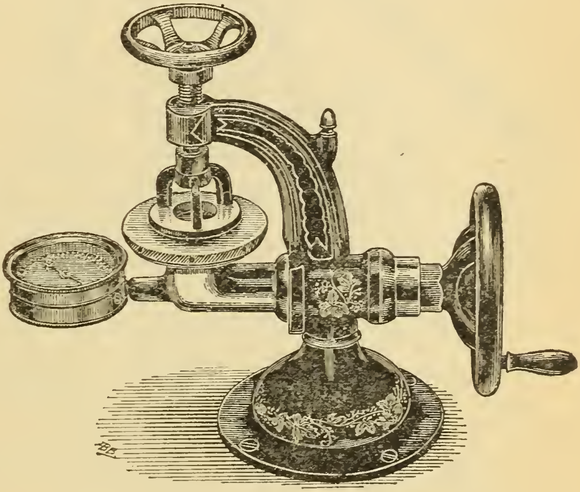

FIG. 2.—Typical American strength tester.

The results are influenced chiefly by the size of the circular piece of paper which is broken, this varying measurably on different machines of the same make, by the force with which the clamp which holds the paper in place is put down, and by the speed at which the pressure is applied. As even the same operator can not always clamp the paper with the same force nor apply the pressure at the same speed, results vary considerably. Furthermore, the gauge is likely to get out of order and give erroneous readings. It must, therefore, be frequently checked against a standard gauge. The paper trade is, however, familiar with the results obtained with this tester, and it does not seem wise to abandon its use at present, particularly as the strength of paper as thus determined is secondary in importance to the folding number presently to be described. For this reason a much more accurate but less widely known foreign tester has not been entirely substituted for that commonly used here. The foreign tester (fig. 3) breaks a strip of paper of definite length and width, registering the breaking strain directly and with much less chance of error than when the first type of tester is used. Results on the same paper agree much more closely, and the stretch, which is an important factor in judging paper, is registered at the same time. Further, the strength both across the sheet and lengthwise can be determined and valuable information as to the formation of the paper thus obtained. While the value and greater accuracy of this machine are well recognized, its substitution for the machine now used is not urged for the reasons stated above. In the following specifications only the results by the American type of tester are given.

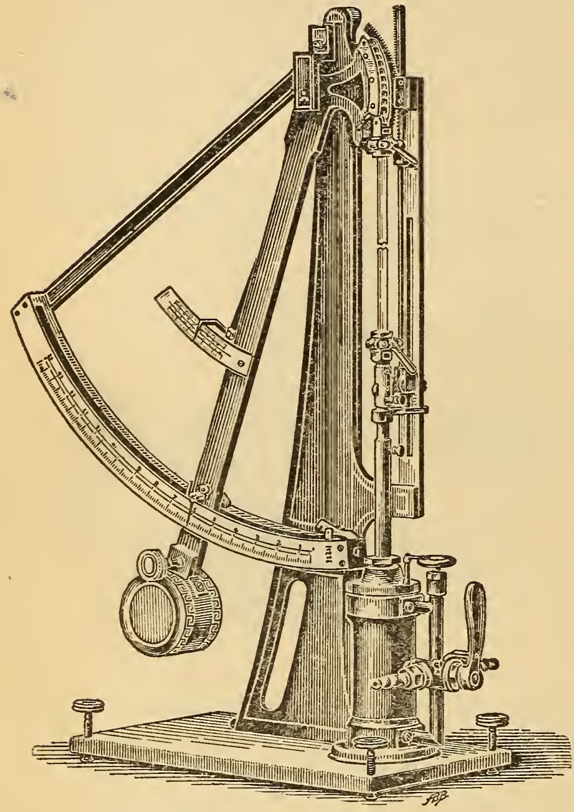

Fig. 3.—Typical foreign strength tester.

FOLDING NUMBER.

The greatest wear upon paper when it is in use is along the line where it is folded upon itself or where it bends when handled. This is the hinge, for example, upon which the sheet turns. If the paper be bound in pamphlet or book form, the strain along this line is greatly increased, owing to the cutting action of the binding thread. If it can not withstand frequent folding, as bonds, maps, and legal papers must, it is soon useless, no matter how strong it may be. In order to determine the resistance of paper to such wear, a machine known as the folder (fig. 4) has been devised, in which a strip 15 mm wide and 95 mm long is folded repeatedly upon itself along the same line, under a constant definite strain of 1 kg until it breaks, the number of folds being automatically registered. Recent work strongly indicates that this is probably the most valuable single test to which paper can be subjected for the purpose of determining its probable durability in actual service. A priori this would appear to be true, as the test is practically a duplication of the conditions under which the paper is employed. Purchasers who desire to secure durable paper should insist upon a high "folding number," as the results by this machine may properly be called. In the following specifications the "folding number" or "folding factor" required can be readily attained by using fair-grade materials and making them into a sheet in accordance with good mill practice.

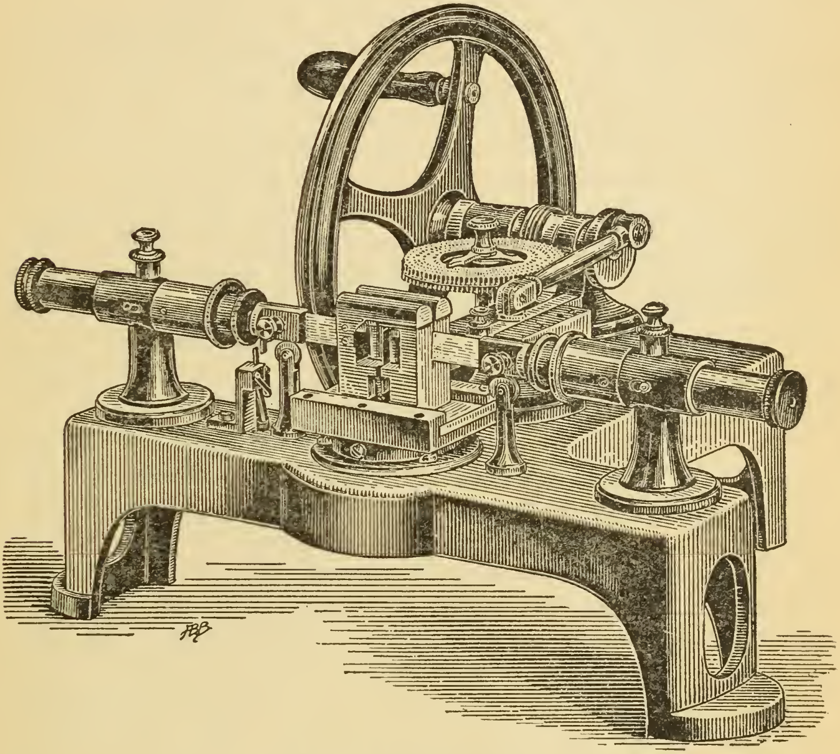

FIG. 4.—Folding machine.

MICROSCOPIC EXAMINATION OF PAPERS.[a]

Papers are subjected to a microscopic examination for the purpose of identifying the stock from which they have been made and to determine in a general way how the fibers have been treated in the several paper-making processes.

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[a] By B. J. Howard, Chief of Microchemical Laboratory.

Specimens to be examined microscopically are sampled by taking small portions from several parts of the sheet, or sheets, and placing them in a beaker where they are boiled from five to ten minutes with a dilute alkali solution. The strength of this solution varies somewhat according to the character of the paper, though it is rare that a strength greater than 0.25 per cent to 0.75 per cent of potassium hydroxid is required. Usually papers sized with rosin require a stronger solution than when gelatin or starch is used.

After boiling, the paper is placed in fresh water in a test tube and shaken vigorously until the fragments have been reduced to a pulp. In some kinds of stock this separation takes place readily (e. g., straw, mechanical wood, and some chemical wood pulps), while in others the fibers felt together so strongly that considerable agitation is required before a satisfactory pulp for examination can be secured.

Small portions of pulp are carefully removed from the well-mixed sample by means of a teasing needle, and after being placed on the slide the excess liquid is removed by a pointed strip of filter paper brought in contact with the edge of the drop. A drop of zinc-chloriodid solution [a] is added and the fibers well separated from each other by use of needles. Finally, the slide is covered. The slide thus prepared is examined under a microscope having a power of about 90. A power of 200 will be found of service at times, though in this laboratory the lower one is commonly used.

It is well to call attention at this point to the lenses most suitable for the work. Although achromatic objectives can be used, the superiority of good apochromatic objectives with the compensating oculars over the ordinary achromatic series is rarely more effectively demonstrated than in this line of work. Chromatic aberration in the lenses is especially objectionable because the colors which are produced by the reagents, and which are so useful in the identification of the fibers, are more or less masked by color defects in many achromatic lenses.

Though other solutions are at times of service, the zinc-chloriodid has proved in our hands the most serviceable. By the colors produced pulps are divided into three or four groups, which are further identified by the size, shape, and markings.

A word or two concerning the colors produced by the zinc-chloriodid reagent may not be out of place. The chemical pulps from woods are colored blue by it when in proper strength, though experience has shown that if the reagent is too strong the color is so intense as to be nearly black and to seriously mask the fiber markings. On the other hand, if it is too weak the color produced is reddish and may approach the color of rag pulp, which should be a rather dull red with a tinge of blue. Straw and mechanical wood give bright brownish yellows, while rope manila and jute give colors from light blue to yellows.

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[a] This reagent is made up as follows: 100 grams of zinc chlorid is dissolved in 60 cc of water to which is then added 20 grams of potassium iodid and 0.5 gram of iodin crystals. A few crystals of iodin should be left in the bottle to insure saturation. Allow the solution to stand a few hours before using. If the color produced in the fibers is too deep a blue, a slight dilution of the reagent is advisable.

In reporting results it has been customary to report all pulps made from cone-bearing trees (spruce, pine, fir, balsam, etc.) as "sulphite," and those from the broad-leaf trees (poplar, basswood, birch, chestnut, etc.) as "soda" pulp. This is not strictly correct, since at present some of the cone bearers are made up by other processes. According to a report by the Forest Service in 1905[a] about 8.3 per cent of the domestic spruce manufactured by chemical processes was made up by the soda method. The sulphate pulp, mostly imported from Europe, is also made from cone-bearing trees. The term "sulphite" and "soda" are therefore misleading when employed in stating the results of a microscopical examination of paper fiber. The term "sulphite" in such a report actually means "coniferous" wood fiber, and the term "soda" means "broadleaf" wood fiber. The term "coniferous wood fiber" embraces fibers or pulps made by any chemical process from pines, hemlocks, cedars, firs, spruces, tamaracks, balsams, etc., while the term "broadleaf wood fibers" includes fibers or pulp made by chemical processes from poplars, aspens, birches, tulip trees, basswood, chestnut, maple, tupelo, catalpa, etc. No method is yet known by which the particular process employed in cooking the pulp can be determined by examining the finished pulp or paper.

The counting method in this laboratory has proven to be the most satisfactory way of estimating the percentage of pulps in a paper. About six slides are made up, as previously described, with chlorzinciodid, mixing the pulp in the tube before each removal. The number of fibers of each kind of pulp is counted in each of 30 to 40 fields—or at least until an aggregate of about 500 fibers has been counted. From the results thus obtained the percentages are calculated. If the analyst practices with samples of known composition he usually, after some experience, will be able to obtain fairly satisfactory results by this method. There are, however, certain conditions which may arise that lessen the accuracy of the method, among which the most important is excessive beating of the pulp stock in the process of manufacture. Again, some of the cone-bearing woods used in making the pulps have fibers which are readily confused with the wood cells of some of the broad-leaf types. Conspicuous among these are some of the hemlocks.

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[a] U. S. Dept. Agr., Forest Service Cir. 44.

With some practice ordinary combinations of rag and chemical wood can be determined within about 5 per cent of the actual amounts present. The composition of combinations of sulphite and soda pulps is much more difficult to estimate, though it can usually be done within 7 per cent. The conditions of manufacture at times make the securing of results even as accurate as these impossible. The fibers of pulp which has been excessively beaten will sometimes be so broken and mangled as to make positive identification impossible, and again pulps that have been over-bleached may be so weakened that in the ordinary beating the fibers will be much torn and distorted. Papers made from old paper will also commonly show an excessive amount of short fragments. The presence of inferior stock of this kind is often indicated by the physical tests, as such treatment tends to lessen the breaking and folding strength.

In this connection the danger of depending too implicitly on descriptions and illustrations of the appearance of fibers under the microscope as a means of identification should be emphasized. If the descriptions are carefully written and the illustrations well made, they will be a valuable secondary aid in classifying the fibers, but such work can not take the place of the actual examination of pulps of known composition in connection with a study of the crude wood or fibers used in their manufacture.

EXPLANATION OF CERTAIN FEATURES OF THE SPECIFICATIONS.

Knowing the factors which affect the quality of paper and the significance of the tests which are employed, specifications may be prepared which will secure papers suitable for various requirements, from the strongest and most durable ledger to the transitory newspaper. It would be impracticable, as well as unnecessary, to give complete specifications involving stock, ash, finish, sizing, strength, thickness, and folding number for all papers of different kinds, weights, and sizes. For the purpose of simplifying the specifications and making them generally applicable to papers of any weight, certain generalizations are made.

In a general way, the strength, thickness, and folding number of paper of a given kind vary proportionally with its weight. This fact is generally recognized and is expressed in the German specifications, in which strength is not stated in terms of the weight required to break a strip 15 mm wide by 180 mm long, the dimensions of the piece of paper actually tested, as this weight would differ with every difference in the weight of the paper. In order to secure values applicable to all weights of paper of the same kind, strength is expressed as the length of a strip of paper which would break of its own weight if suspended by one end. This is known as the "breaking length." It is calculated by the following formula:

Breaking strain (in grams) multiplied by the length of strip (in millimeters) divided by the weight (in milligrams) of strip tested equals breaking length (in meters). Applying this same principle to the results obtained with the testing machines used in the United States this bureau proposes certain factors which are applicable to papers of given classes. These factors are quite simple in their derivation and are adopted rather than the German system for the reasons previously advanced—to simplify the methods as much as possible and to base them as far as practicable on testers in general use in this country. This principle is in use among paper makers in calculating equivalent strength and thickness for papers of the same general class. Therefore its extension to this use is not only logical but involves the introduction of nothing with which the paper-making industry is not familiar.

" Strength factor " is the number obtained by dividing the strength of the paper as determined on the rubber diaphragm paper tester by the weight in pounds of a ream 24 by 36, 500. Thus, if a 24 by 36, 500, 40-pound paper has a strength of 16 pounds, the strength factor is 16 divided by 40, or 0.4.

" Minimum strength factor " means that the number so obtained shall not be less than the stated figures, but may be greater, provided the paper is otherwise satisfactory.

The strength, expressed in pounds, which a particular paper should have to comply with specifications is found by multiplying its weight per ream by the " strength factor " for that kind of paper.

The folding number is the number of double folds which the paper endures under a strain of 1 kg before breaking. The folding factor is obtained as follows: A strip of the paper 15 mm in width is folded forward and backward on itself while under a strain of 1 kg. The number of double folds required to break the paper divided by the weight in pounds of a ream of the paper 24 by 36, 500, gives the folding factor. A preliminary test is made and the paper is folded in the direction giving the lowest folding number.

" Minimum folding factor " means that the number so obtained shall not be less than the stated figures, but may be greater provided the paper is otherwise satisfactory. The number of double folds or folding number which a given paper should have to comply with these specifications is found by multiplying the weight per ream 24 by 36, 500, by the folding factor for that kind of paper.

" Thickness factor " is the number obtained by dividing the average thickness of a sheet of paper, expressed in ten-thousandths inch, by the weight in pounds of a ream 24 by 36, 500. Thus, if a 24 by 36, 500, 60-pound paper is 42 ten-thousandths inch thick, the thickness factor is 42 divided by 60, or 0.7.

"Maximum thickness factor" means that the number so obtained shall not be greater than the stated figures. How thick a given paper must be to comply with these specifications is determined by multiplying its weight per ream 24 by 36, 500, by the thickness factor for that kind of paper.

The strength and folding tests are made at a relative atmospheric humidity of from 60 to 70 per cent, and when made at any other degree of humidity are corrected by suitable factors.

"Maximum ash" means that the ash must not exceed the stated percentage, but may be less, provided the paper is otherwise satisfactory.

The "rise of water" in blotting paper is obtained by dipping one end of a vertical strip in water and noting the height to which the water rises in ten minutes.

These specifications do not include requirements as to color, surface, appearance, and feel of the paper. These can not be expressed intelligibly in figures or in words, at present. Furthermore, any or all of these may be varied to suit individual tastes and other requirements without departure from the specifications.

As a guide to the paper maker, specifications for paper should always be accompanied by a sample to show the finish, color, and general appearance desired. If this sample also complies with the specifications in every particular, the paper maker is much assisted in his efforts to make the desired paper, and can make a much more accurate estimate of the probable cost. This sample should be about 10.5 by 16 inches, and the specification in full should be printed or typewritten thereon.

In the course of this investigation about 5,000 papers were examined, and the results obtained on approximately the best third were used as a basis for the specifications here given. They are not, therefore, an expression of the average results obtained for the whole of any one class of papers, nor are they based on the very highest results obtained, and hence it is not difficult to secure papers in any class much superior to those demanded by the specifications. It is not deemed wise, however, for the reasons previously stated, to make them more stringent at the present time.

GENERAL REQUIREMENTS.

All paper should be well made, uniform in formation, color, finish, weight, and thickness, and should be as clean and free from dirt as the highest art of paper making will secure. Printing and writing papers must not contain free acid, alkali, or bleaching materials and must be well washed to remove soluble salts. Failure to meet any one of these requirements may properly constitute cause for rejection of delivery.

The average variation in the weight per ream and in thickness of sheet in a delivery should not exceed 2 per cent above nor 4 per cent below the ordered weight and thickness, paper within this range to constitute a good delivery.

When stock of a definite kind is specified the percentage of the most valuable material should not average more than 4 per cent below the specified percentage, nor should individual deliveries testing more than 7 per cent below the specified percentage be accepted.

Printing and writing papers should be properly sized for the respective classes. Printing paper should be so sized as to give satisfactory presswork with standard printing inks. Writing inks should not run on writing papers. No percentage of sizing materials can be specified other than to say that the minimum amount to secure satisfactory results should be used.

SPECIFICATIONS FOR PRINTING PAPERS.

Under this heading may be included machine finish and supercalendered printing papers, coated papers, and map and plate papers. The tendency in the manufacture of modern printing papers has been to a bulky, heavy, soft sheet, possessing great opacity. Weak, nondurable papers have resulted from accentuating these characteristics. A great deal more attention should be directed to the production of stronger, more durable, less bulky, and lighter papers which have good printing qualities and opacity. Very white papers with smooth surfaces are not only objectionable in that they are less durable but they are also harmful to the eyesight. Physicians, teachers, and others who have investigated the matter agree that often the defective eyesight and headache prevalent among school children are directly due to the use of very white highly surfaced paper in schoolbooks. Cream colored or natural papers of rather rough surface are to be preferred from the combined viewpoint of service, health, and good taste. Needlessly heavy or thick paper is objectionable because it is more difficult to handle and occupies more room on the shelves.

MACHINE FINISH, FIRST-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock: All rag.

Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Minimum strength factor		0.4
Minimum folding factor		.4
Maximum thickness factor	Lighter than 36 pounds	.9
	Heavier than 35 pounds	.8

DETAIL SPECIFICATIONS FOR 25-POUND PAPER.

Stock: All rag.

Ash: Maximum (per cent)	5
Rosin: Maximum (per cent)	1
Weight, ream 24 by 36, 500 (pounds)	25
Minimum strength (pounds)	10
Minimum folding number	10
Maximum thickness (thousandths inch)	2.25

Finish: Machine, uniform, and same on both sides.

This paper is of the highest quality as to stock and care in manufacture. It is suggested for very heavy and voluminous publications, primarily works of reference, or indexes containing more than 1,500 pages. Paper for these publications should be strong, light, and thin. The fact that they are rather transparent is a minor objection, because the publication is not read continuously, but consulted intermittently. A number of different finishes can be given the paper.

DETAIL SPECIFICATIONS FOR 30-POUND PAPER.

Stock: All rag.

Ash: Maximum (per cent)	5
Rosin: Maximum (per cent)	1
Weight, ream 24 by 36, 500 (pounds)	30
Minimum strength (pounds)	12
Minimum folding number	12
Maximum thickness (thousandths inch)	2.7

Finish: Machine, uniform, same on both sides.

This paper is of the highest quality as to stock and methods of manufacture. It is suggested for heavy and voluminous publications, designed to last indefinitely, or publications which are frequently handled or subjected to other very severe usage. Journals which are subsequently to be bound in a single volume, works of reference, dictionaries, enclycopedias, etc., containing no half-tone illustrations in the text may be printed upon this paper with satisfactory results. Paper of this grade and class should also be employed in a few copies intended for permanent records of voluminous publications printed on much inferior paper. A few copies of government and state departmental reports and bulletins of all kinds should be printed thus for library use and for permanent records. The bulk and weight of such publications are much reduced by using this paper. It is rather more transparent than a heavier paper, but not sufficiently so to interfere with the legibility of print or to be annoying if not read continuously.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock: All rag.

Ash: Maximum (per cent)	5
Rosin: Maximum (per cent)	1
Weight, ream 24 by 36, 500 (pounds)	40
Minimum strength (pounds)	16
Minimum folding number	16
Maximum thickness (thousandths inch)	3

Finish: Machine, uniform, and same on both sides.

This is a high-quality paper with respect both to stock and to methods of manufacture. It is suitable for publications which should last for one hundred years or more and for those which are frequently handled or subjected to other severe usage. Paper of this weight and thickness answers all practical purposes, and is recommended for very durable publications of all kinds. but especially for those containing less than 600 pages. The paper is sufficiently opaque for continuous reading, and is especially recommended to librarians and publishers for books for public libraries. Paper of this grade should also be employed in a few copies intended for permanent records, of those publications which are printed on much inferior paper. A few copies of government and state departmental reports and bulletins of all kinds should be printed thus for library use and for permanent records. The use of this paper will reduce rebinding expenses and save shelf space and weight. It is not suitable for half-tones requiring much detail, but when well finished may be used for line cuts and half-tones showing but little detail.

MACHINE FINISH, SECOND-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Minimum strength factor		0.40
Minimum folding factor		.25
Maximum thickness factor	Lighter than 36 pounds	.9
	Heavier than 35 pounds	.8

DETAIL SPECIFICATIONS FOR 30-POUND PAPER.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Weight, ream 24 by 36, 500 (pounds)		30
Minimum strength (pounds)		12
Minimum folding number		7
Maximum thickness (thousandths inch)		2.7

Finish: Machine, uniform, same on both sides.

This is a fine-grade paper with respect both to stock and to methods of manufacture. It is but little less durable and only slightly weaker than first-grade paper. with which it agrees in thickness, weight, and finish. It is suggested for heavy and voluminous publications designed to last well under much handling, long storage, or other severe usage. Journals which are subsequently to be bound in a single volume, works of reference, dictionaries, and encyclopedias, containing no half-tone illustrations in the text, may be printed upon this paper with satisfactory results. The bulk and weight of such publications are much reduced by using this paper. It is rather more transparent than a heavier paper, but not sufficiently so to interfere with legibility, nor to be harmful or annoying to the eyes if not read continuously.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock	Rag (per cent)	75
	Bleached and chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Weight, ream 24 by 36, 500 (pounds)		40
Minimum strength (pounds)		14
Minimum folding number		10
Maximum thickness (thousandths inch)		3.2

Finish: Machine, uniform, and same on both sides.

This is a fine-quality paper, both in stock and in methods of manufacture. It is but little less durable than first-grade paper, with which it agrees in weight, thickness, and finish. Paper of this weight and thickness answers all practical purposes and is recommended for durable publications of all kinds, but especially for those containing less than 600 pages. The paper is sufficiently opaque for continuous reading and is recommended to librarians and publishers for publications of all kinds which require a fine paper but not the very best quality. It will answer nearly the same purposes as the first grade, except that it is less durable.

MACHINE FINISH, THIRD-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock	Rag (per cent)	40
	Bleached chemical wood or equivalent (per cent)	60
Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Minimum strength factor		0.35
Minimum folding factor		.25
Maximum thickness factor	Lighter than 36 pounds	.9
	Heavier than 35 pounds	.8

DETAIL SPECIFICATIONS FOR 30-POUND PAPER.

Stock	Rag (per cent)	40
	Bleached chemical wood or equivalent (per cent)	60
Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Weight, ream 24 by 36, 500 (pounds)		30
Minimum strength (pounds)		10.5
Minimum folding number		7
Maximum thickness (thousandths inch)		2.7

Finish: Machine, uniform, and same on both sides.

This is a medium quality paper as to stock, but should be made with all the precautions taken in making better papers. It is less durable and weaker than second-grade paper, with which it agrees in weight, thickness, and finish. It is suitable for heavy or voluminous publications, designed to last about one hundred years or less, with moderate handling and fair storage conditions. Journals which are subsequently to be bound in a single volume, works of reference, dictionaries, and encyclopedias containing no half-tone illustrations in the text, matter which will be out of date within one hundred years, may be printed upon this paper. The bulk and weight of such publications are kept within reasonable limits by the use of this paper. Its transparency is greater than that of heavier paper, but not sufficiently so to be annoying or injurious when not read continuously.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock	Rag (per cent)	40
	Bleached chemical wood or equivalent (per cent)	60
Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Weight, ream 24 by 36, 500 (pounds)		40
Minimum strength (pounds)		14
Minimum folding number		10
Maximum thickness (thousandths inch)		3.2

Finish: Machine, uniform on both sides.

This is a medium quality paper as to stock, but should be made with all the care taken in making better paper. It is less durable and weaker than second-grade paper, with which it corresponds in weight, thickness, and finish. Paper of this weight and thickness answers all practical purposes, and is recommended for publications of all kinds designed to last one hundred years or less with moderate handling, storage, and other conditions. It is best suited for publications containing less than 600 pages. The paper is sufficiently opaque for continuous reading, and is recommended as a medium-grade general-purpose paper.

MACHINE FINISH, FOURTH-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock: Bleached chemical wood or equivalent.

Ash: Maximum (per cent)		5
Rosin: Maximum (per cent)		1
Minimum strength factor		0.35
Minimum folding factor		.2
Maximum thickness factor	Lighter than 36 pounds	.9
	Heavier than 35 pounds	.8

DETAIL SPECIFICATIONS FOR 30-POUND PAPER.

Stock: Bleached chemical wood or equivalent.

Ash: Maximum (per cent)	5
Rosin: Maximum (per cent)	1
Weight, ream 24 by 36, 500 (pounds)	30
Minimum strength (pounds)	10.5
Minimum folding number	6
Maximum thickness (thousandths inch)	2.7

This is a fair grade paper as to stock, and should be made with nearly as much care as is taken in making better grade paper. It is less durable and weaker than third-grade paper, with which it agrees in weight, thickness, and finish. It is the lowest quality paper that should be used except for the most transitory purposes. It is suitable for heavy or voluminous publications designed to last possibly fifty years with very moderate handling and other favorable conditions. Journals which are subsequently to be bound in a single volume, works of reference, dictionaries, encyclopedias, census reports, departmental reports, voluminous government, state, and other reports of all kinds intended for free distribution, containing matter which is out of date within fifty years, may be printed upon this paper. It is more transparent than a heavier paper, but not sufficiently so to be objectionable for intermittent reading.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock: Bleached chemical wood or equivalent.

Ash: Maximum (per cent)	5
Rosin: Maximum (per cent)	1
Weight, 24 by 36, 500 (pounds)	40
Minimum strength (pounds)	14
Minimum folding number	8
Maximum thickness (thousandths inch)	3.2

Finish: Machine, uniform, same on both sides.

This is a fair grade paper as to stock, and should be made with nearly as much care as better papers are. It is less durable and weaker than third-grade paper, with which it corresponds in weight, thickness, and finish. It is the lowest quality of paper that should be used except for the most transitory purposes. Paper of this weight and thickness answers all general purposes and is recommended for publications of all kinds designed to last less than fifty years with little handling and under other favorable conditions. It is particularly suitable for the briefer government and state publications intended for free distribution, notably consular reports, printed bills, departmental bulletins, experiment station bulletins, railroad schedules, price lists, and many other publications containing matter which will be out of date or useless within fifty years. This paper is sufficiently opaque for continuous reading.

MACHINE FINISH, FIFTH-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock: Any acceptable.

Ash: Maximum (per cent)	10
Minimum strength factor	0.2
Maximum thickness factor	.8

DETAIL SPECIFICATIONS FOR 35-POUND PAPER.

Stock: Any acceptable.

Ash: Not more than (per cent)	10
Weight per ream 500 sheets, 24 by 36 (pounds)	35
Strength (pounds)	7

Finish: Machine, uniform.

This is a low-grade paper and need not be made with great care as its life is but short. Large quantities of paper are employed for printing proof, posters, advertising, and for other temporary uses, and a paper complying with the above specifications will answer all ordinary purposes.

SUPERCALENDERED, FIRST-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock: All rag.

Ash: Maximum (per cent)		10
Rosin: Maximum (per cent)		2
Minimum strength factor		0.4
Minimum folding factor		.35
Maximum thickness factor	Lighter than 36 pounds	.8
	Heavier than 35 pounds	.7

Supercalendered paper is suitable for use when coarse-line half-tones, not finer than 135 lines to the inch, are used in the text or when it is desired to reduce bulk as much as possible. The reflecting surface is injurious to the eyes, and for this reason the use of supercalendered papers should be avoided when possible.

DETAIL SPECIFICATIONS FOR 32-POUND PAPER.

Stock: All rag.

Ash: Maximum (per cent)	10
Rosin: Maximum (per cent)	2
Weight, ream 24 by 36, 500 (pounds)	32
Minimum strength (pounds)	13
Minimum folding number	11
Maximum thickness (thousandths inch)	2.6

Finish: Supercalendered, uniform, and same on both sides.

This is a high-quality paper both as to stock and as to method of manufacture. It is suitable for heavy or voluminous publications designed to last indefinitely or to be frequently handled or subjected to other severe usage. It is suitable for all purposes where 30-pound first-grade, machine-finish paper may be used, and, further, is especially to be preferred when half-tone illustrations not requiring great detail are to be used in the text. Calendered papers reflect the light more than rough-surfaced papers and are consequently more tiresome as well as more injurious to the eyes, and should only be used when necessary. The paper is rather more transparent than a heavier paper, but not sufficiently so to interfere with the legibility of print or to be annoying if not read continuously.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock: All rag.	
Ash: Maximum (per cent)	10
Rosin (per cent)	2
Weight, ream 24 by 36, 500 (pounds)	40
Minimum strength (pounds)	16
Minimum folding number	14
Maximum thickness (thousandths inch)	2.8
Finish: Supercalendered, uniform, and same on both sides.	

This is a high-quality paper with respect both to stock and to methods of manufacture. It is suitable for publications designed to last indefinitely or which are frequently handled or are subjected to other severe usage. Paper of this weight and thickness answers all practical purposes and is recommended for very durable publications of all kinds but especially for those containing less than 600 pages and employing half-tone illustrations in the text. The paper is sufficiently opaque for continuous reading and is especially recommended to librarians and publishers for books for public libraries or for use in those cases in which 40-pound first-grade machine-finish paper may not be employed owing to its unsuitability for half-tone work.

SUPERCALENDERED, SECOND-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		10
Rosin (per cent)		2
Minimum strength factor		0.35
Minimum folding factor		.25
Maximum thickness factor	Lighter than 36 pounds	.8
	Heavier than 35 pounds	.7

DETAIL SPECIFICATIONS FOR 32-POUND PAPER.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		10
Rosin: Maximum (per cent)		2
Weight, ream 24 by 36, 500 (pounds)		32

Minimum strength (pounds)		11
Minimum folding number		8
Maximum thickness (thousandths inch)		2.6

Finish: Supercalendered, uniform, same on both sides.

This is a fine-grade paper with respect both to stock and to methods of manufacture, and is similar in all respects except finish to 30-pound second-grade machine-finish paper, and may be employed in all cases for which that grade is employed, particularly when half-tone illustrations not finer than 125 lines per inch in the text are desired.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		10
Rosin: Maximum (per cent)		2
Weight, ream 24 by 36, 500 (pounds)		40
Minimum strength (pounds)		14
Minimum folding number		10
Maximum thickness (thousandths inch)		2.8

Finish: Supercalendered, uniform, same on both sides.

This paper is similar to 40-pound second-grade machine-finish paper, except that it is calendered instead of having a machine finish. It is suitable for use in all cases where the corresponding grade of machine-finish paper may be employed, and particularly when half-tone illustrations not finer than 125 lines per inch are desired in the text.

SUPERCALENDERED, THIRD-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock	Rag (per cent)	40
	Bleached chemical wood or equivalent (per cent)	60
Ash: Maximum (per cent)		10
Rosin: Maximum (per cent)		2
Minimum strength factor		0.35
Minimum folding factor		.2
Maximum thickness factor	Lighter than 36 pounds	.8
	Heavier than 35 pounds	.7

DETAIL SPECIFICATIONS FOR 32-POUND PAPER.

Stock	Rag (per cent)	40
	Bleached chemical wood or equivalent (per cent)	60
Ash: Maximum (per cent)		10
Rosin: Maximum (per cent)		2
Weight, ream 24 by 36, 500 (pounds)		32
Minimum strength (pounds)		11
Minimum folding number		6
Maximum thickness (thousandths inch)		2.6

Finish: Supercalendered, uniform, same on both sides.

This paper is similar to 30-pound, third-grade, machine-finish paper, except that it is calendered instead of having a machine finish. It is suitable for use in all cases where the corresponding machine-finish paper may be employed, and particularly when half-tone illustrations not finer than 125 lines to the inch are desired in the text.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock	Rag (per cent)	40
	Bleached chemical wood or equivalent (per cent)	60
Ash: Maximum (per cent)		10
Rosin: Maximum (per cent)		2
Weight, ream 24 by 36, 500 (pounds)		40
Minimum strength (pounds)		14
Minimum folding number		8
Maximum thickness (thousandths inch)		2.8
Finish: Supercalendered, uniform, same on both sides.		

This paper is similar to 40-pound, third-grade, machine-finish, except that it is calendered. It is suitable for use in all cases where a machine-finish paper of equal quality may be employed, and especially when half-tone illustrations not finer than 125 lines per inch are desired in the text.

SUPERCALENDERED, FOURTH-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock: Bleached chemical wood or equivalent thereof.		
Ash: Maximum (per cent)		10
Rosin: Maximum (per cent)		2
Minimum strength factor		0.3
Minimum folding factor		.1
Maximum thickness factor	Lighter than 36 pounds	.8
	Heavier than 35 pounds	.7

DETAIL SPECIFICATIONS FOR 32-POUND PAPER.

Stock: Bleached chemical wood or equivalent thereof.	
Ash: Maximum (per cent)	10
Rosin: Maximum (per cent)	2
Weight, ream 24 by 36, 500 (pounds)	32
Minimum strength (pounds)	10
Minimum folding number	3
Maximum thickness (thousandths inch)	2.5
Finish: Supercalendered, uniform, same on both sides.	

This paper is similar to 30-pound fourth-grade machine-finish, except that it is calendered instead of having a machine finish. It is suitable for use in all cases where the corresponding machine-finish paper may be employed and especially when half-tone illustrations are desired in the text.

DETAIL SPECIFICATIONS FOR 40-POUND PAPER.

Stock: Bleached chemical wood or equivalent.	
Ash: Maximum (per cent)	10
Rosin: Maximum (per cent)	2
Weight, ream 24 by 36. 500 (pounds)	40
Minimum strength (pounds)	13
Minimum folding number	4
Maximum thickness (thousandths inch)	2. 8
Finish: Supercalendered, uniform, same on both sides.	

·This paper is similar to 40-pound fourth-grade machine-finish, except that it is calendered instead of having a machine finish. It is suitable for use in all cases where the corresponding machine-finish paper may be employed, and especially when half-tone illustrations not finer than 125 lines to the inch are desired in the text.

ANTIQUE, FIRST-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		2
Rosin: Maximum (per cent)		1
Minimum strength factor		0. 4
Minimum folding factor		. 4
Maximum thickness factor		1

Antique paper is made light and bulky. As it is not closely woven it is as a rule weaker than ordinary printing paper made from the same grade of materials. It is largely used in novels and other publications to increase their bulk. It is a paper of good appearance, the chief objection to it being that ordinarily it is not strong and durable, and publications printed on it occupy much room. The above specifications will secure a first-class, durable paper. It is not a paper of great utility and is used chiefly where appearance is the controlling factor, and for this reason specifications for but two grades are given.

ANTIQUE, SECOND-GRADE PAPER.

GENERAL SPECIFICATIONS.

Stock	Rag (per cent)	40
	Bleached chemical wood or equivalent (per cent)	60
Ash: Maximum (per cent)		2
Rosin (per cent)		1
Minimum strength factor		0. 2
Minimum folding factor		. 1
Maximum thickness factor		1

This is a good grade, suitable for use when a bulky paper of fair quality is desired.

UNCOATED HALF-TONE PAPER, FIRST GRADE.

GENERAL SPECIFICATIONS, 10 PER CENT ASH.

Stock: All rag.	
Ash: Maximum (per cent)	10.0
Minimum strength factor	0.5
Minimum folding factor	3.0
Maximum thickness factor	.8

There is a need for a high-grade uncoated paper suitable for half-tone work in publications of great value. For these publications durability and the certainty that the leaves will not stick together are of more importance than great detail in the half-tone. A paper made along the lines of these specifications, with a high plate or supercalender finish, is suitable for the purpose. Screens having as many as 135 lines to the inch may be employed in the half-tones. Papers weighing from 60 to 80 pounds per ream 24 by 36, 500, are suggested as preferable in most cases to the 90 to 120 pound papers usually employed.

GENERAL SPECIFICATIONS, 25 PER CENT ASH.

Stock: All rag.	
Ash: Maximum (per cent)	25.0
Minimum strength factor	0.4
Minimum folding factor	1.0
Maximum thickness factor	.8

Paper made along the line of these specifications, in which the highest possible finish is given to the surface, is suggested for half-tone work requiring considerable detail. The use on this paper of half-tones having more than 150 lines per inch is not advised. The use of coated papers, as now made, in publications of value can not be too strongly discouraged. The stock used in such papers is usually not durable, and should the paper become damp the pages are almost certain to stick together and thus be ruined. Furthermore the nature of the coating material renders it liable to deterioration through attack of insects and bacteria.

COATED BOOK PAPERS, FIRST GRADE.

GENERAL SPECIFICATIONS (COATED ON BOTH SIDES).

Stock: All rag.	
Ash: Maximum, calculated per ream, basis 24 by 36, 500 (pounds)	20
Coating: Glue and clay, but must not contain casein.	
Minimum strength factor	0.4
Minimum folding factor	.4
Maximum thickness factor	.7

This is a first-class paper in stock and methods of manufacture. It is suitable for half-tone illustrations and should have the maximum durability under severe handling, storage, and other adverse conditions. Paper weighing from 60 to 70 pounds per ream, 24 by 36, 500, is suggested as being heavy enough for all practical purposes, and if a coated paper must be used it is recommended for durable and valuable publications. Both sides may be used for printing the illustrations. Coated papers owe their value primarily to evenness of the surface and adhesiveness of the coat to the paper. Unfortunately, no suitable tests are known, other than a working test, for these properties. Depending on the character of surface, these papers can be used with half-tones containing 400 lines to the inch.

GENERAL SPECIFICATIONS (COATED ON ONE SIDE).

Stock: All rag.	
Ash: Maximum, calculated per ream, basis 24 by 36, 500 (pounds)	10
Coating: Glue and clay, must not contain casein.	
Minimum strength factor	0.4
Minimum folding factor	.4
Maximum thickness factor	.7

This is a high-quality paper, both in stock and in methods of manufacture. It is suitable for half-tone illustrations and has the maximum durability under severe handling, storage, and other adverse conditions. Paper weighing 55 to 70 pounds per ream, 24 by 36, 500, is sufficiently heavy for all practical purposes, and if a coated paper must be employed this is recommended for durable and valuable publications. Only the coated side can be used for illustrations. Use this paper when placing half-tones on but one side of the paper.

COATED BOOK PAPERS, SECOND GRADE.

GENERAL SPECIFICATIONS (COATED ON BOTH SIDES).

Stock: Bleached chemical wood or equivalent thereof.	
Ash: Maximum per ream, basis 24 by 36, 500 (pounds)	20
Minimum strength factor	0.30
Minimum folding factor	.08
Maximum thickness factor	.60

This is a good grade paper in stock and should be made with all the precautions taken in making a better paper. It is suitable for half-tone illustrations in less durable publications of all kinds and may be employed when it is desired to place illustrations on both sides of the sheet. Paper weighing from 60 to 75 pounds per ream, 24 by 36, 500, is sufficiently heavy for all practical purposes.

GENERAL SPECIFICATIONS (COATED ON ONE SIDE).

Stock: Bleached chemical wood or equivalent thereof.	
Ash: Maximum per ream, basis 24 by 36, 500 (pounds)	10
Minimum strength factor	0.30
Minimum folding factor	.08
Maximum thickness factor	.60

This is a good grade paper in stock and should be made with all the precautions taken in making a better paper. The paper is suitable for half-tone illustrations in less durable publications of all kinds where but one side of the paper is to be used for the illustration. Paper weighing from 60 to 75 pounds per ream, 24 by 36, 500, is sufficiently heavy for all practical purposes. Use this paper when placing half-tones on but one side of the paper.

MAP AND CHART PAPER, GENERAL SPECIFICATIONS.

Stock: All rag.

Ash: Maximum (per cent)	2
Minimum strength factor	0. 6
Minimum folding factor	4
Maximum thickness factor	. 75
Maximum expansion when wetted (per cent)	2. 5

This is a high-quality paper, both in stock and in methods of manufacture. It is suitable for use in all cases where very durable and resistant map paper is required, and is strongly recommended in such cases. The finish may be glazed or unglazed, as desired. Avoid the use of needlessly heavy paper. If lower quality map papers are desired, supercalendered printing paper, second, third, and fourth grades, may be employed. Bond papers are also frequently used for maps.

PLATE PAPER, GENERAL SPECIFICATIONS.

Stock: All rag.

Ash: Maximum (per cent)	5
Strength factor	0. 3–0. 4
Thickness factor	. 9–1

Should be as free as possible from spots and specks of any kind, and be perfectly suitable for plate printing.

Paper for engraving should be of the best quality, free from imperfections and from chemicals that may affect the printing inks. It should have an even surface and be neither too hard nor too soft. Paper complying with the above general specifications has proved satisfactory. The color may be very white or cream or natural, as desired. Very white papers are, as a rule, less durable than cream-colored papers, because they are usually more severely bleached.

PHOTOGRAPHIC PRINTING PAPERS, GENERAL SPECIFICATIONS.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash, per ream, 24 by 36, 500 (pounds)		15
Minimum strength factor		0. 7

The paper and coating must not contain iron or copper particles.

Photographic paper should be perfectly clean and free from foreign materials, otherwise the image is likely to fade and the paper to discolor in time. To prevent fading and discoloring it is most important after the execution of the chemical processes involved in making the print that the chemicals be thoroughly washed out of the paper.

SPECIFICATIONS FOR WRITING PAPERS.

Writing paper is commercially subdivided into a number of classes, according to the purpose for which it is used. The characteristics of these classes differ widely, as certain purposes require paper of the highest quality while others call for but little better than low-grade printing paper. Writing papers in general differ from printing papers in that they are made from better stock and are beaten and run to give a stronger and therefore more transparent sheet. They are sized with glue as well as with rosin, and the stock is severely bleached to give a very white paper. This very white paper, being only obtained by severe bleaching, either of the cotton or linen fabric before it reaches the paper mill or subsequently of the half stuff in the mill, is likely to prove much less durable than paper made from the same materials not so severely bleached. The latter will not be so white, however. The purchaser should bear in mind, therefore, that in demanding a very white paper, rather than a natural or cream-colored paper, he is likely to secure a less durable paper, and furthermore, one that is more trying and harmful to the eyesight. As with other papers the purchaser is urged to use paper no heavier than is needed, thus effecting a saving in freight, postage, and handling charges, as well as in the first cost of the paper.

Writing papers should be sufficiently sized to give a satisfactory surface for writing ink. Excess of sizing materials should be avoided, however, as all organic sizings cause discoloration and deterioration.

LEDGER PAPER, FIRST GRADE.

Stock: All rag.

Ash: Maximum (per cent)	1
Minimum strength factor	1
Minimum folding factor	10
Maximum thickness factor	0.75

This paper should be made of new rags. It must be strong to withstand much handling, and firm and well sized in order to leave a good surface after erasure. Paper complying with the above specifications is better and will prove more durable than much of the ledger paper now used. It will prove satisfactory for the most exacting requirements. Those who desire that their accounts and records be permanent should assure themselves that the ledger paper employed is fully as good as called for by these specifications. Heavy ledger paper will be found suitable for card indexes, which are handled a great deal and subjected to fraying, breaking on the corners, and bending. The preparation of a card index is laborious and costly, and for this reason, if for no other, only the best card should be used.

LEDGER PAPER, SECOND GRADE.

Stock	Rag (per cent)	75
	Bleached chemical wood or equivalent (per cent)	25
Ash: Maximum (per cent)		1
Minimum strength factor		0.80
Minimum folding factor		2
Maximum thickness factor		.75

A ledger paper somewhat inferior and less durable than the first grade is frequently employed. This specification will secure a high-grade paper which will give good service and meet all but the most exacting requirements.

PARCHMENT OR PARCHMENT DEED PAPERS.

Stock: All rag.

Ash: Maximum (per cent)	1
Minimum strength factor	1
Minimum folding factor	5
Maximum thickness factor	0.8

This is a high-grade paper suitable for the most exacting use for deeds, certificates, legal forms, bonds, and other records of value which are subjected to much handling and folding and where permanency is essential. Much of the paper now used in recording deeds, wills, mortgages, and other state and county legal proceedings is of poor quality and unsuitable for the purposes for which it is employed. State and county purchasing officers should always assure themselves that the paper bought for the above-mentioned purposes complies in all particulars with the above specifications, and is at the same time clean, firm, and well made. Many court records are no longer available because the paper used for them could not stand the constant handling to which it was subjected. They must therefore be copied, involving greater expense than would have been incurred in securing a first-class paper in the first instance. Those responsible for these records may look forward to their early uselessness unless they avail themselves of all means to obtain the best papers.

BOND AND LETTER PAPERS, FIRST GRADE.

Stock: All rag.

Ash: Maximum (per cent)	1
Minimum strength factor	0.8
Minimum folding factor	3
Maximum thickness factor	.85

This is a high-grade paper suitable for bonds, high-grade commercial stationery partaking of the nature of permanent records, carbon copies, statements, billheads, receipts, etc., and for other important records. It is but little less durable under severe handling and folding than parchment deed paper, and may be employed for records kept flat.

THIN BOND OR ONION-SKIN PAPER.

Stock: All rag.

Ash: Maximum (per cent)	1
Minimum strength factor	0.7
Minimum folding factor	2.0
Maximum thickness factor	.8

This specification will insure a high-grade paper suitable for manifolding, foreign correspondence, or interleaving.

BOND PAPER, SECOND GRADE.

Stock	Rag (per cent)	50
	Bleached chemical wood or equivalent (per cent)	50
Ash: Maximum (per cent)		2
Minimum strength factor		0.7
Minimum folding factor		2.0
Maximum thickness factor		.8

This will insure a fair-grade bond paper suitable for ordinary business correspondence and for bills, statements, etc. Necessarily such a paper has not the quality of higher grade, but the above specifications will insure a fair-grade paper much superior to ordinary bond paper. It is also suitable for so-called "safety papers," which are surface colored in such a way that erasure either by rubbing or the use of chemicals can be detected. This paper is employed in making checks, notes, drafts, money orders, etc.

WRITING PAPER, MEDIUM GRADE.

Stock	Rag (per cent)	60
	Bleached chemical wood or equivalent (per cent)	40
Ash: Maximum (per cent)		2
Minimum strength factor		0.6
Minimum folding factor		.8
Maximum thickness factor		.75

This paper is suitable for general correspondence, bills, statements, etc., when a medium-grade rather than the best paper is desired.

WRITING PAPER, LOW GRADE.

Stock: Bleached chemical wood or equivalent thereof.

Ash: Maximum (per cent)	2
Minimum strength factor	0.40
Minimum folding factor	.25

This is a low-grade writing paper for use where permanency or resistance to wear and tear is not required.

ENVELOPE PAPER. MEDIUM GRADE.

Stock	Rag (per cent)	50
	Bleached chemical wood or equivalent thereof (per cent)	50
Ash: Maximum (per cent)		2
Minimum strength factor		0.5
Minimum folding factor		.25

Envelopes may, of course, be made of any grade of writing paper, and frequently the paper used for the accompanying letter paper is employed. As envelopes are but short-lived they need not be of strong rag papers. It is sufficient that they have a good writing surface, be opaque, strong enough to carry their contents safely, and appear well when delivered.

For ordinary white and colored commercial envelopes, of which large quantities are made, the above specification is proposed. Experience shows that a paper of this quality and strength answers all ordinary requirements, as to both durability and appearance.

SPECIFICATIONS FOR BLOTTING PAPERS.

Blotting papers may properly be divided into two classes; the first is employed only for absorbing ink, the second for desk pads. The first class should take up ink rapidly, but should not rub off or become rough when rubbed with the fingers, as in the act of blotting. The second class may have a closer texture and harder finish to enable it to resist wear when used as a desk pad.

As a rule, blotting papers contain more or less rag stock, but as the percentage of rag does not appear to bear any important relation to absorptive power, and as ordinary blotting papers will usually endure longer than they will retain a high absorptive efficiency, the specification of a definite percentage of rag stock is not deemed necessary. These specifications are intended to permit the employment of any desired percentage of rag or chemical wood stock.

ORDINARY BLOTTERS.

Stock: Bleached chemical wood or equivalent thereof.

Ash: Maximum (per cent)	10
Rise of water in ten minutes (mm)	80

The essential characteristic of blotting paper is to absorb ink rapidly and repeatedly. A paper which raises water to a height of 80 mm in ten minutes is better than the average found on our market, and but little more than two-thirds as good as the best.

DESK BLOTTERS.

Stock: Bleached chemical wood or equivalent thereof.

Ash: Maximum (per cent)	15.00
Strength factor	0.10
Rise of water in ten minutes (mm)	60

SPECIFICATIONS FOR WRAPPING PAPER.

The essential characteristics of wrapping papers are strength, pliability, and resistance to wetting. These papers need not be durable, as they serve but a temporary purpose. A great deal of money, time, energy, and raw material are wasted in making low-grade wrapping paper. It is customary to secure strength in these papers by making a heavy paper of low-grade materials by inferior methods of manufacture. The use of lighter and better papers would save the purchaser money and conserve raw materials. For example, 20-pound No. 1 jute, 25-pound kraft, 40-pound No. 1 manila, and 70-pound bogus manila have about the same strength and are about equally serviceable for wrapping purposes. Their present prices per pound are 4.75, 4.50, 2.85, and 1.20 cents, respectively. The cost per ream is therefore as follows: No. 1 jute, 95 cents; kraft, $1.12; No. 1 manila, $1.14; and bogus manila, 92 cents. A ream of first-class paper, therefore, such as No. 1 jute, costs less than a ream of an inferior paper, such as No. 1 manila.

FIRST-GRADE WRAPPING PAPER.

Minimum strength factor	1.2
Minimum folding factor	10

This specification will insure a wrapping paper of the highest quality, and it is doubtful whether it can be produced except by the use of manila, jute, or equally strong fibers. It is suitable for wrapping packages subjected to severe handling, for envelopes often handled in the mail, strong bags for the hardware and seed trade, etc.

SECOND-GRADE WRAPPING PAPER.

Minimum strength factor	0.7
Minimum folding factor	5

This specification will insure a wrapping paper strong enough for all but the most exacting requirements. It meets the ordinary trade requirements for the wrapping paper used in bags as well as for the so-called manila envelopes. This paper in 25 pounds per ream will give as good service as the ordinary 50-pound bogus manila now commonly employed. This paper is superior in every way to nine-tenths of the wrapping paper now found on the market. The use of a lower grade paper than this for wrapping purposes is not advised.

SPECIFICATIONS FOR COVER PAPERS.

Cover papers are largely used on pamphlets of all kinds. While they can not reasonably be expected to last in hard service, they should withstand a reasonable amount of handling, present an attractive appearance, and protect the pamphlet.

FIRST-GRADE COVER PAPER.

Stock: Bleached chemical wood or equivalent thereof.

Ash: Maximum (per cent)	2
Minimum strength factor	0.4
Minimum folding factor	.4

A cover paper complying with the above specifications should prove satisfactory where fine appearance and considerable resistance to wear are desired. Covers of paper are not expected to be permanent and therefore great strength is not required. A paper of this quality is suitable for covers for briefs, specifications, and fine pamphlets. When very durable covers are desired the paper should contain a large proportion of rag stock.

LOW-GRADE COVER PAPER.

Ash: Maximum (per cent)	6
Minimum strength factor	0.3
Minimum folding factor	.2

This is better than much low-grade paper and will prove suitable for temporary purposes.

SPECIFICATIONS FOR BOARDS.

The very thick papers, or boards, as they are called, are used for many purposes, some of which require great resistance to wear. If a board is sufficiently strong to serve the purpose for which it is designed, it will usually prove entirely satisfactory, and for this reason strength only is specified, except in the case of bristol board, employed for visiting and business cards, where other characteristics are also desired.

FIRST-GRADE BRISTOL.

Stock	Rag (per cent)	50
	Bleached chemical wood or equivalent (per cent)	50
Ash: Maximum (per cent)		1
Minimum strength factor		0.6
Maximum thickness factor		.7

This specification will secure a bristol board suitable for practically all purposes.

SECOND-GRADE BRISTOL.

Stock: Bleached chemical wood or equivalent thereof.

Ash: Maximum (per cent)	2
Minimum strength factor	0.5
Maximum thickness factor	.7

MANILA TAG BOARD.

This board should have a minimum strength factor of 1. Tag board is subjected to very rough usage, which nothing but a strong board will withstand. It is economy to buy a light, strong board in preference to a heavy board of the same strength.

CARDBOARD.

Cardboard should have a minimum strength factor of 0.35. Box boards, china board, railroad board, and lithograph blanks may be included under this specification.

○

[illegible]

Douglas